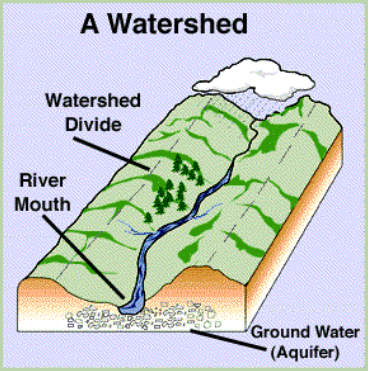


What is a watershed?

No matter where you live, work, or play, you are in a watershed. A watershed is a geographic area where all water drains to a specific location. This location may be a stream, river, lake, wetland, ocean, or the water may drain underground into the groundwater. A creek drains a small watershed, while a river drains a larger watershed. Every creek, stream, or river that drains into another body of water is considered a tributary to that body of water. The watershed boundaries for a large body of water will include many smaller tributary watersheds. A surface watershed is defined by the surrounding topography. A watershed extends from the end of the drainage area (the lowest point) upgradient to all the highest points that surround the drainage channel.

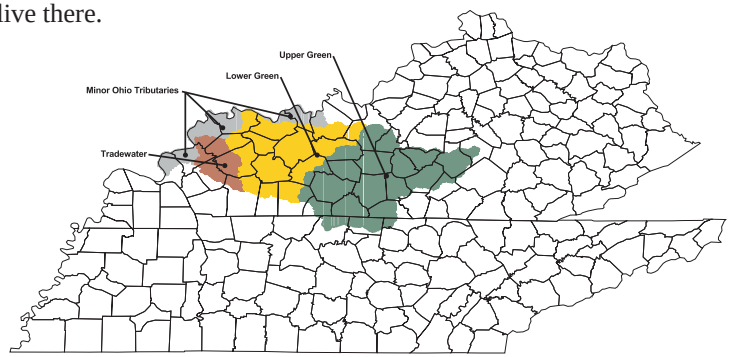
Description of the Green and Tradewater basins

To understand the health of the watershed, one must also understand the natural conditions of the watershed. The geology, or physiographic makeup of the basin, the type of terrain, the amount of water, population, land-use activities, etc., all have a bearing on where and how pollutants move in the environment and how we are exposed to them. In the end, these natural conditions affect the health of the watershed and the people who live there.

Regions of the watershed

For the purpose of this report, the Green River basin is divided into two regions based on hydrologic units, which divide the overall Green River watershed into sub-basins defined by tributaries within the basin. On this basis, the part of the watershed upstream from the Green's junction, or confluence, with the Barren River near Woodbury is considered the **Upper Green River** basin. Similarly, the areas that drain to the Green downstream from this point will be referred to as the **Lower Green River** basin.

This report also deals with all of the Tradewater River drainage basin, plus a few smaller watersheds that are minor tributaries to the Ohio River.



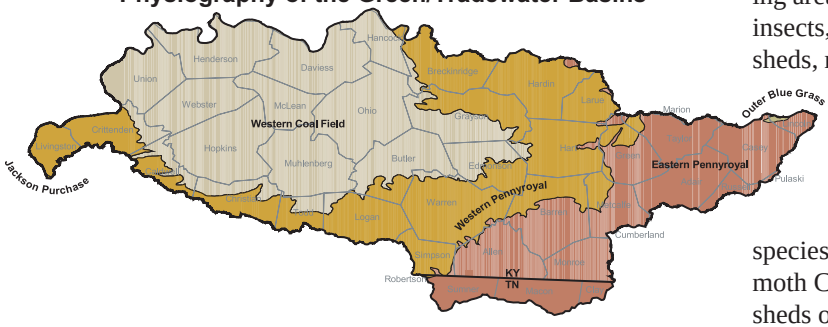
Physiography

The physiography of a region is influenced by a variety of underlying features. Most important is the type and geometry of bedrock in the area. Surface and groundwater flows are controlled by the nature of these rocks and the associated surface features. There are two main physiographic regions through which the Green and Tradewater Rivers flow. The **headwaters of the Green River** lie in the region known as the Eastern Pennyroyal. Most of this area is characterized by flat-lying limestones, sandstones, and shales that underlie flat to gently rolling terrain. The limestone areas have well-developed karst topography, characterized by vast sinkhole plains that take virtually all surface water that comes to them and channel it through caves and smaller underground passages below the ground surface. Several springs in this region, discharging from major underground passages, are large enough to support municipal water systems. The **Lower Green River** traverses the Western Coalfield. This region consists primarily of thick flat-lying sandstone and shale beds and is generally characterized by flat to gently rolling terrain. Groundwater flow is predominantly through fractures, with wells in valleys typically producing more water than wells on ridges. The upper part of the **Tradewater River** Region flows northward from the Western Pennyroyal. As it approaches its confluence with the Ohio River, it flows over gently rolling terrain underlain mainly by loose sediments such as sand and silt. Groundwater flow there is primarily through the spaces between the grains of sediment. Shallow wells in the area are widely used for domestic water supplies; in addition, deeper wells in confined aquifers provide abundant water for industrial, municipal, and domestic use.

What's different about these watersheds?

In most landscapes, slopes control the runoff from precipitation and stream drainage, with ridgelines forming the drainage boundaries. Underground water in most watersheds and drainage basins tends to follow the lay of the land. However, in soluble limestone terrain or karst regions, the underground drainage may differ from the boundary of its surface watershed and flow through caves and cracks in the rocks beneath the surface ridges. This is sometimes called "misbehaved" karst drainage. In the Mammoth Cave region, 15%-20% of the underground water is misbehaved.

Physiography of the Green/Tradewater Basins



Is the watershed healthy?

Watershed health is the main question this report explores. In order to determine if the region's streams are impaired or contaminated, we have reviewed water sampling data, assessments of stream and river bank conditions, discharge permits for wastewater treatment plants, and activities like farming, development, logging, and mining. What happens in the river basin – or *watershed* – directly impacts water quality and habitat conditions. According to current records, some tributaries in the Green River basin and the Tradewater River region are contaminated by agriculture (293 miles of streams), resource extraction (242 miles), municipal impacts (186 miles), man-made drainage changes (141 miles), and waste disposal on the land (86 miles**)**. These sources of pollutants contribute bacteria from sewage or livestock; silt from erosion, construction, or logging; algae blooms fed by nutrients from fertilizers or manure; and various pollutants from mining and industrial or urban wastewater plants. Unfortunately only 22% of the basin's streams have been assessed. Most of the streams in the region, however, seem to be free of excessive pollution. Maintaining good water quality in the unpolluted parts of the river and cleaning up contamination in other sections will require a closer look at what is happening in the watershed, how it impacts watershed health, and what can be done to improve conditions.

Biodiversity

Because of the variety of biological and physiographic regions that occur in the Green River and the Tradewater River region, the natural biodiversity is high compared with many surrounding areas. For example, great diversities of fish, aquatic insects, and freshwater mussels are found in these watersheds, many of which exist only in this part of the nation and should be protected. The Green River in Hart, Barren, and Edmonson counties flows through one of the most significant areas for unique cave species diversity in the United States. These rare and endangered cave-dwelling invertebrate species have not been fully identified; therefore, the Mammoth Cave area, in particular along the edges of the watersheds outside of the National Park, requires further study.

Natural biological systems help humans by filtering and cleansing water and storing and detoxifying pollutants. But the loss of habitat or excessive pollution and/or siltation can threaten biodiversity. The Kentucky Biodiversity Task Force is an excellent source of information on the status of Kentucky's plant and animal biodiversity. Visit its website at *http://www.nr.state.ky.us/nrepc/dnr/ksnpc/biodiv.htm.*

Floodplain Management

As more and more development occurs, land becomes a premium. Unfortunately, good land for farming and development is often located in the floodplain. When development occurs in the floodplain, several potential problems arise. First and foremost, people and property are at risk during a flood event. Many lives and millions of dollars have been lost to flooding in Kentucky. Ninety-six counties and close to 300 municipalities in Kentucky have established a floodplain management program that tries to protect the floodplain and minimize threats to people and property. Thirteen of the 34 counties in the Green/Tradewater rivers region have yet to adopt a floodplain management program; but, within some of those counties, municipalities have enacted their own floodplain management ordinances for their citizens. Only communities and/or counties that adopt a Flood Damage Prevention Ordinance and submit an application to the Federal Emergency Management Agency (FEMA) are eligible to purchase federal flood insurance. Flood insurance is not available in counties and municipalities that have not joined the National

Basin or Watershed?
The basin of a river, stream, or lake is all the land that is drained by the river, stream, or lake. Another word for basin is watershed, which comes from the observation that water is shed from an area of land and flows downhill into a body of water.

Geography and Stream Health
How does geography affect the health of streams? The lay of the land, soil types, and vegetation in an area can directly affect water quality -- especially when the land is cleared or tilled. For example, basins with loose soils, steep hills, or little vegetation are often severely eroded by rainstorms, leaving streams and rivers muddy and subject to flooding from rapid runoff. Vegetation can reduce flooding by slowing down runoff from rainstorms and can even filter out silt and other contaminants before they reach streams. Trees, bushes, and tall grass along stream banks also reduce erosion along the channel and create valuable habitat for birds, mammals, and other creatures.

Biodiversity
Biodiversity is the number and kind of organisms present, including bacteria, plankton, plants, fungi, and animals. The degree of biodiversity is both affected by;, and impcts upon, the health and function of streams, lakes, and wetlands.

Mammoth Cave National Park adds significantly to the natural and recreational resources of the region and attracts a number of out of state tourists. The Mammoth Cave National Park website is: http://www.nps.gov/maca/

Karst Topography
Karst topography is defined as that type of terrain and geologic region underlain by bedrock that dissolves easily, such as limestone, and characterized by depressions in the ground (sinkholes), caves, and underground drainage. Because water can enter the subsurface easily through caves and cracks in the soluble limestone bedrock, karst groundwater is highly susceptible to contamination.

Flood Insurance Program. One means for measuring the potential threat to a community is by the amount of property insured against flood damage. More than $224 million worth of property is insured against flood damage in the region. Since 1978, more than $15 million in flood insurance claims have been paid in the region, with more than $9 million of that figure in Christian County alone.

Natural and Recreational Resources

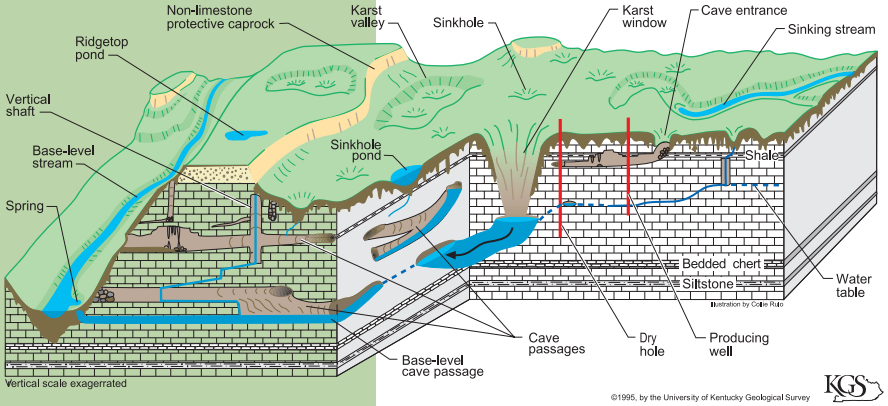
A number of natural and recreational resources exist in the Green River Basin, making it necessary to strike a balance between the economics of the area's tourism and environmental protection.

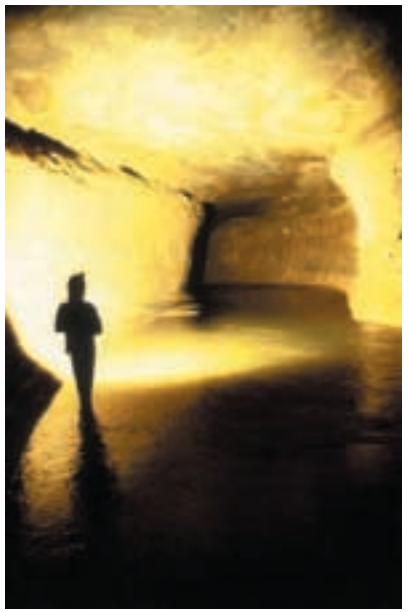
Mammoth Cave The major natural resource of the area is the renowned Mammoth Cave and the region's karst topography; however, there are a number of other special natural resources, including significant fisheries, threatened and endangered mussels, and wildlife management areas.

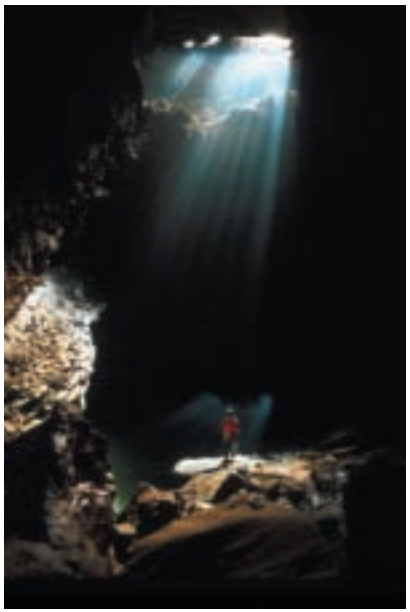
Reservoirs The Army Corps of Engineers (COE) plays a major role in providing for flood protection and recreation in the Green River Basin. Although the four reservoirs, Barren, Green, Nolin and Rough River lakes, were built primarily for flood protection, they have taken on a significant role as important regional recreational resources. The lands leased for state parks, campsites, and outdoor activities, along with areas managed by the COE, add significantly to the recreational benefits of the region. The remaining land and water owned by the COE are managed by the Kentucky Department of Fish and Wildlife Resources (KDFWR) as part of a management agreement between the COE and KDFWR. The lakes provide habitat for a number of species of popular gamefish, including largemouth bass, hybrid striped bass, crappie, channel catfish, sunfishes, and flathead catfish. In addition, there are hunting areas for cottontail rabbits, quail, squirrels, turkey, waterfowl, morning doves, and whitetail deer. These reservoirs contain a number of conservation efforts and recreational opportunities. Visit this Web site for more information:

http://www.lrl.usace.army.mil/or/or_pages.htm

Block diagram of karst features







Two underground rivers within the Green River Basin: Lost River in Warren County (left) and Hawkins River in Edmonson County (right).

Green River Bioreserve The Nature Conservancy's (TNC) conservation program, Green River Bioreserve, was established as a landscape-scale, community-based conservation effort in recognition of the value of the Green River's biodiversity. Work will begin on the ground level with agencies, conservation groups, communities, and private landowners. TNC and the COE are working cooperatively with a variety of state/federal agencies and academic partners to propose modifications in flow and temperature management of the Green River Lake reservoir to recapture more natural patterns of variation, while still meeting the demands for reservoir recreation, flood storage, and flood control. TNC is also the local sponsor and cost-sharing partner with the COE on a Section 1135 Environmental Restoration project for bank stabilization/bioengineering and riparian restoration on the Green River just below the confluence with Russell Creek.

The Green River Bioreserve, consisting of the Upper Green River, its tributaries, and portions of Mammoth Cave National Park, comprises a watershed of approximately 1,350 square miles. This watershed is among the most significant of aquatic ecosystems in North America. Its characteristic landscape features, including much karst topography, habitat diversity, and geographic location, contribute to form one of North America's foremost centers for unique qualities and biodiversity. The Green River Bioreserve supports nearly 60 species of freshwater mussels, one of the world's most imperiled organism groups. There is one freshwater mussel species that can be found only in Kentucky, and then only here. Of the Green River's 151 fish species, 109 are found within the bioreserve. Seven of these species are found only in Kentucky, and at least 12 fishes are considered globally rare. A number of rare, threatened, or endangered plants and other animals are also native to the Green River Bioreserve. An altered hydrological regime, local land-use practices, bank erosion, agricultural runoff and other nonpoint source pollution, and rural development are primary threats. A study performed in the Upper Green River basin has revealed several priority sites in need of improved conservation practices.

Water Resources

The Green River and Tradewater watersheds are unrivaled water resources within Kentucky and our nation. Karst topography is a natural feature of these watersheds. Because of the rich supply of streams, other surface waters, and karst topography, water use (including drinking water) relies heavily on both surface water and groundwater sources. The nature of karst topography results in an intermingling of surface water and groundwater. Interactions of karst topography, surface water, and groundwater produce water supplies that are extremely vulnerable to poor land-use practices.

With approximately 27,668 miles of surface streams in these two watersheds, the importance of protecting and enhancing watershed health is obvious. An abundance of water creates many important habitats and supplies many needs. With the confluence of many small streams in the eastern headwaters of the Green River watershed, the rivers become much larger and broader in the western region of Kentucky. The gentle terrain, soil types, and geology of the lower portions of the Tradewater and Green Rivers create river flows that produce wide meanders. As a result of the physical surroundings, the rivers frequently receive much of their stream flow from pockets of wetlands scattered about the western region. Wetlands in this region play a critical role in flood control by slowly releasing water to the rivers after a rain event. During periods of drought, wetlands help maintain base flow levels for fisheries and drinking water supplies in area rivers. Additionally, these wetlands provide critical habitat for wildlife, filter out pollutants, and help to sustain watershed health.

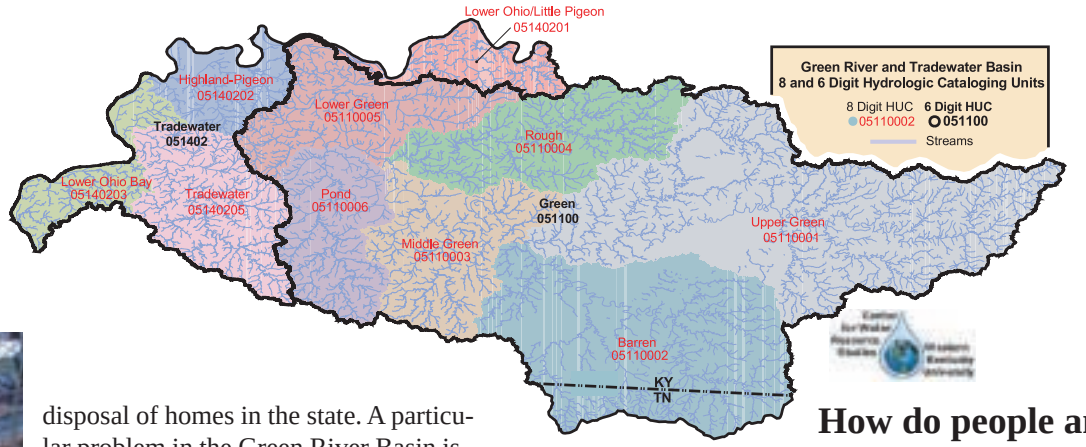
Wastewater

A large volume of wastewater is discharged in this region from industrial facilities and sewage treatment plants. A sanitary sewage treatment system and any other type of industrial or process wastewater plant must have a Kentucky Pollutant Discharge Elimination System (KPDES) permit and meet specific discharge quality standards. "On-site" wastewater systems, such as septic systems, are used throughout most of the basin and comprise about 40% of the wastewater

Drinking Water Supplies
Source water for drinking must be piped from groundwater (wells and springs) or surface water supplies to the users. Public drinking water utilities have to be concerned with the quantity and quality of the supply in order to meet the needs of the public. Both factors can be greatly affected by droughts and upstream activities. While the water is treated prior to distribution, the raw water that comes from the well, lake, or river must be of high enough quality to allow safe treatment. During periods of drought or heavy rainfall, the quality can be adversely affected by discharges of wastewater or pollutants that run off the land, making protecting the drinking water source and its watershed even more important to everyone.

Consumer Confidence Reports
The Safe Drinking Water Act requires that all community water systems annually report to water users information about the quality of the water delivered by the system. These public reports are available from each drinking water provider and describe water sources, water distribution, detected contaminants, and water quality violations with associated public health information.

Connectivity
The uniqueness of karst watersheds strongly reflects the connectivity of the land to the water and to public health.



disposal of homes in the state. A particular problem in the Green River Basin is that septic systems often do not perform properly within the extensive karst regions because of inadequate filtration and rapid drainage into the groundwater system. Some homes do not have proper wastewater disposal systems; these "straight pipes" release raw sewage to creeks, rivers, or to unconfined underground cavities and pose a significant health threat.

In areas where there are recreational boats, discharge and disposal of wastewater can also be a serious problem. Correction of this problem will involve installation of pump-out and treatment facilities at marinas, along with education of the boating public. Many of the larger recreational lakes in Kentucky have marine waste pump-out stations.

Waste Disposal

Most solid waste goes to contained landfills, which are designed to capture any leachate (contaminant-laden water) that may be produced. Unfortunately, open dumps are all too common. Illegal dumps in sinkholes in the karst plain of central and south central Kentucky are a particular problem. Sinkhole dumps pose a serious threat to human health and the environment because they drain directly to groundwater where they can contaminate drinking water supplies.

Under a statewide campaign, thousands of dumps have been cleaned up, millions of waste tires have been picked up, and several new programs have been initiated.

Owensboro wastewater treatment plant

How do people and land use affect a watershed?

All land-use activities, including agriculture, landfills, coal mines, logging, gas and oil production, concentrated animal feeding operations and urban sprawl, affect water quality. The predominant land-use activities within a watershed are good indicators of the potential contaminant sources within that watershed.

Agricultural land represents about 54.6% of the region and is used to grow crops or raise farm animals. Farming utilizes chemicals such as fertilizers, herbicides, or insecticides that could be carried off into a stream by stormwater runoff. Other impacts include soil erosion, resulting in sediments entering the streams, and pathogens and nutrients from animal wastes entering the streams.

Forest land represents about 39.1% of the region and may be a natural area that is relatively undisturbed or an area where intensive harvesting occurs or something in between. Most of these forests are deciduous; about one-tenth represent evergreen forest types. A forest area that is managed as a natural area may have relatively little or no impact on the waters within the watershed. However, a forest that is harvested for lumber and poorly managed may impact the watershed through soil erosion (primarily from logging roads).

Residential land includes small communities and suburban areas of homes. Land disturbance during construction as well as land changes affect the hydrology of streams. Many homes

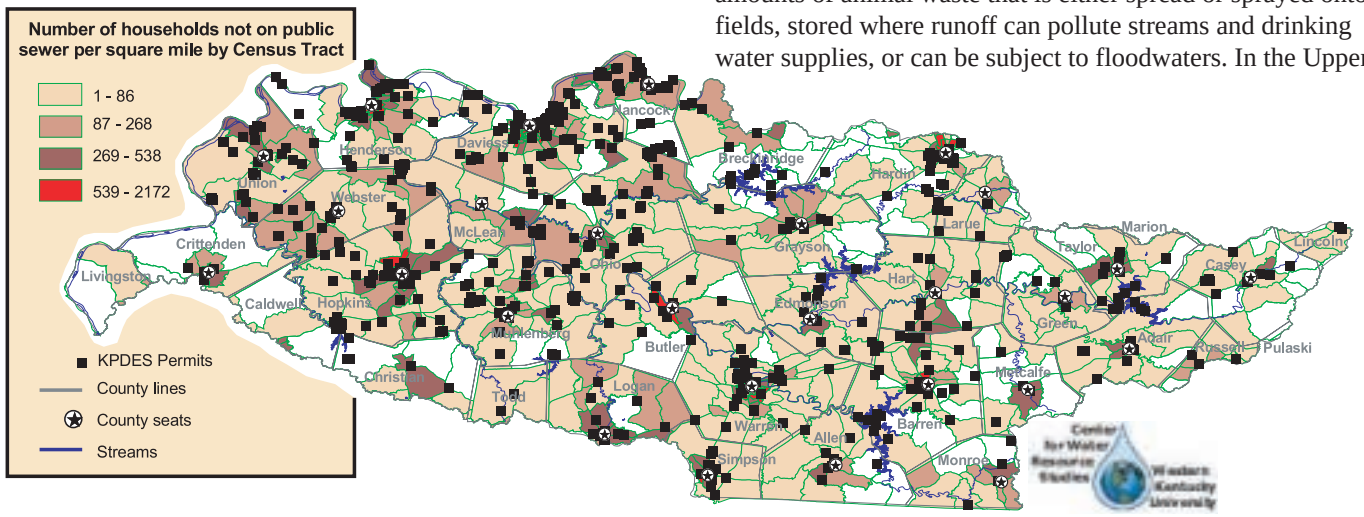
depend on septic tanks, which, if not properly maintained, may be sources of bacteria, pathogens, and nutrients. Chemicals applied to lawns, trees, and shrubs by homeowners, such as fertilizers, insecticides, and herbicides, are carried off by stormwater and may harm the quality of the water in the creeks or harm the animals and plants in the creek. Stormwater runoff from cities contains automotive oils, sediment from land-clearing activities, particulates from cars and other sources, nutrients that feed algae blooms, and other urban contaminants. The loss of greenspace to development of new buildings, roads, and parking lots also causes surges in stream levels due to rapid runoff that erodes stream banks and can cause localized flooding. These changes also reduce groundwater recharge, so stream flows in summer months are lower. Finally, the loss of trees, shrubs, and grasses along stream banks causes further instability and erosion, with resulting increases in siltation and decreases in both in-stream and stream-bank habitat. Channelization, the clearing and straightening of stream channels, aggravates both flooding and sedimentation, despite the common notion that it reduces flooding. This is a very widespread practice in the Lower Green River part of the watershed. Urban, or built-up land, represents about 2.7% of the region.

Water resources represent about 2.1% of the total land cover in this region, as estimated by land-use grids. Note that none of the abundant underground water flows in this region are reflected in this value.

Barren land (1.1% of the area) uses include transitional areas, strip mines, quarries, and transportation corridors. No land-use data is available for 0.1% of the region.

Because agriculture is the predominant land use, livestock operations become significant in the watershed. A large percentage of Kentucky's livestock operations are located in the Green River Basin: 69% of the state's Concentrated Animal Feeding Operations (CAFOs) and 46% of its Animal Feeding Operations (AFOs). Under the 1974 Clean Water Act, CAFOs are generally defined as livestock operations of 1,000 animal units or more (for example, 1,000 cattle, 2,550 grown or 10,000 immature swine, or 100,000 chickens). An operation smaller than this is termed an AFO, but may also be defined as a CAFO if it is known to be a significant source of water pollution.

Concentrated Animal Feeding Operations that raise poultry and hogs present a particular threat to the Tradewater/ Lower Green watershed, as these CAFOs produce vast amounts of animal waste that is either spread or sprayed onto fields, stored where runoff can pollute streams and drinking water supplies, or can be subject to floodwaters. In the Upper



Riparian buffer

Riparian area
Stream banks and the land along them are called a riparian area. With appropriate vegetation, riparian areas provide natural protection from pollutants that drain off the land. Good riparian management can prevent erosions and flooding.

Manure crib

KPDES Permits
The State of Kentucky requires all point source discharges of pollutants to the waters of the Commonwealth to be permitted. This includes stormwater runoff discharges from certain types of industries and construction sites exceeding five (5) acres. The permitting program known as the Kentucky Pollution Discharge Elimination System (KPDES) is managed by the Division of Water. Any person or entity proposing a new discharge must submit an application for approval at least 180 days prior to the proposed date that discharge is anticipated.

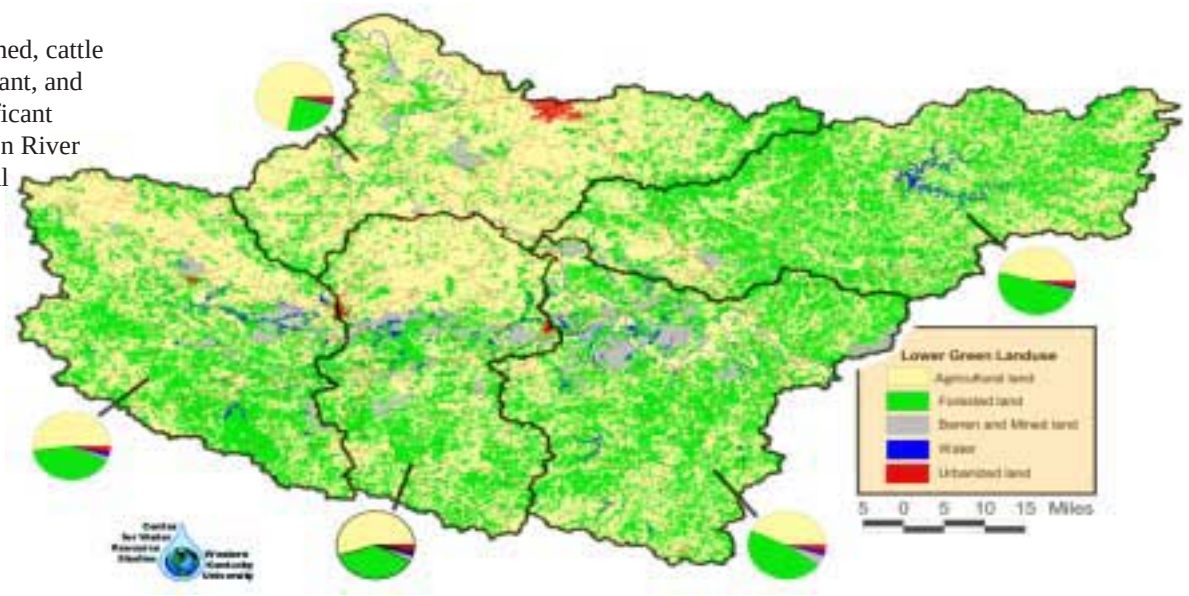
What are AFOs and CAFOs?

An Agricultural Feeding Operation (AFO) is defined as a lot or facility where animals are confined and maintained for a total of 45 days or more in any 12-month period and are fed by means other than grazing. Concentrated Animal Feeding Operations (CAFOs) must meet the definition of an AFO, and there must be a specified number of animals confined at the operation. A facility is a CAFO if the operation contains more than 300 Animal Units confined and there is a discharge to the waters of the Commonwealth or if there are more than 1000 Animal Units confined. The vast majority of operations in Kentucky qualify as CAFOs because they have more than 1000 Animal Units. What are "Animal Units?" 1000 Animal Units are equal to:

- **Beef** — 1000 head of cattle
- **Dairy** — 700 head of cattle
- **Swine** — 2500 pigs, each weighing more than 55 lbs.
- **Poultry** — 100,000 laying hens or broilers

Operations that are defined as CAFOS are required to obtain a Kentucky Pollutant Discharge Elimination System (KPDES) Permit.

Poultry houses



Green River watershed, cattle AFOs are predominant, and they can have significant impacts on the Green River streams and physical damage to stream banks where cattle are unfenced. Fecal contamination can come from chicken and hog manure disposal sites, which are located throughout the basin. Because of the prevalent karst topography in the Upper Green and the abundance of surface water in the Tradewater/Lower Green, this basin can be easily impaired by large concentrations of livestock animals. Excess nutrients (nitrogen and phosphorus) from animal wastes can cause algal growth, which reduces oxygen in the water and can result in fish kills. Animal wastes produced in CAFOs and AFOs also contain pathogens, high amounts of antibiotics, and heavy metals. These can seep into groundwater or wash into rivers and streams.

There is a minimum of 19 million chickens in the Green River basin, according to the Kentucky Division of Water. In McLean County alone, there are almost 250 poultry houses along the Green River. In addition, there were commercial processing plants, at least 36 swine CAFOs, and 130 poultry CAFOs in the Green River/Tradewater basin as of January 2001.